CHAPTER 7

ALARM SYSTEMS

Many buildings and complexes being constructed today are equipped with some type of intrusion detection and fire alarm systems. You, as a Construction Electrician, will be challenged to install, troubleshoot, and maintain these systems. Numerous detection and fire alarm systems are in existence today. In this chapter, we will discuss the function and operation of a typical detection system and of various fire alarm systems. When you are in charge of the installation or maintenance of either a detection or a fire alarm system, you should acquire reference material, such as manufacturer's literature. If such material is unattainable, look at NAVFAC MO-117, *Maintenance of Fire Protection Systems,* which provides an excellent description of several fire alarm systems. Design Manual 13.02, *Commercial Intrusion Detection Systems (IDS),* provides descriptions of various intrusion detection systems.

The purpose of any alarm system is to either protect life or property or to detect an intrusion. Alarm systems are set up to (1) give early warning so occupants may evacuate the building and (2) notify the fire department and/or security soon enough that they have time to react.

TYPES OF FIRE ALARM SYSTEMS

Building alarm systems may be local or local with base alarm system connections. They may be coded or noncoded and may operate either on line-voltage or low-voltage electric power. Their characteristics are described in the following paragraphs.

NONCODED ALARM SYSTEMS

A noncoded alarm system has one or more alarm-indicating appliances to alert the building occupants of a fire but does not tell the location or the type of device that has been activated (manual alarm or automatic protection equipment). The audible and/or visual alarm appliances operate continuously until they are turned off, until a predetermined time has passed, or until the system is restored to normal. The location or type of device originating the alarm condition can be determined by using an annunciator system. An annunciator is a visual-indicating device that will be discussed later in this chapter.

CODED ALARM SYSTEMS

A coded alarm system has audible and/or visual alarm signals with distinctive pulsing or coding to alert occupants to a fire condition and to the location or type of device that originated the alarm. Coding the audible appliances may help personnel to distinguish the fire alarm signal from other audible signals. Clear and early recognition of the signal should encourage a more orderly and disciplined evacuation of the building. A common characteristic of coded alarm systems, especially of selective coded and multiplex coded systems, is that the coded alarm identification provided by the audible alarm signals is not repeated continuously. Normally, after four complete repetitions of the coded signal, the coding process ends.

THEORY OF OPERATION

In the event of a fire, a certain sequence of events has to occur for any alarm system to be effective. First, the fire has to be detected. This can be done by any of the following means: visually and by operation of a manual pull box, heat detectors, water pressure/flow switches, flame-actuated detectors, or smoke detectors. Any of these devices will initiate a signal to the fire alarm control unit, which is powered by a reliable power supply. (See fig. 7-1.) Second, the control unit accepts the signals from the initiating circuits and, through relays or other circuitry, provides the power to operate the indicated devices. These alarm devices may include, but are not limited to, horns, bells, chimes, flashing lights, or annunciators. Finally, operation of the alarm will alert personnel to evacuate and assist fire-fighting personnel in locating the fire, thus protecting life and property.

In the following paragraphs, we will discuss the principle of operation of the associated equipment that makes up an alarm system.

EQUIPMENT DESCRIPTION

Figure 7-1 shows how the basic parts of a local fire alarm system are interconnected. The devices in the diagram are grouped for convenience in labeling. Physical location and zoning of devices vary for different applications, and many systems do not have all the devices shown.

POWER SUPPLIES

Fire alarm systems are in two general categories, as determined by the voltage at which the systems operate: line voltage or low voltage. Regardless of the operating voltage, a system may be noncoded or coded.

Many older local alarm systems are powered by alternating current (ac) power only with no provision for standby battery power. In these cases, two separate ac circuits (usually 120/240 Vac) are used: one to power the fire alarm system operating circuits and another to power the trouble-signaling circuits of the system. Low-voltage alarm systems, especially those provided with battery standby power, are most often found where some form of automatic fire detection or automatic fire extinguishing is connected to the alarm system. However, recent conversion by most alarm system manufacturers to solid-state electronic design, which is essentially a low-voltage direct-current (dc) technology, means that most recent installations are of the low-voltage type.

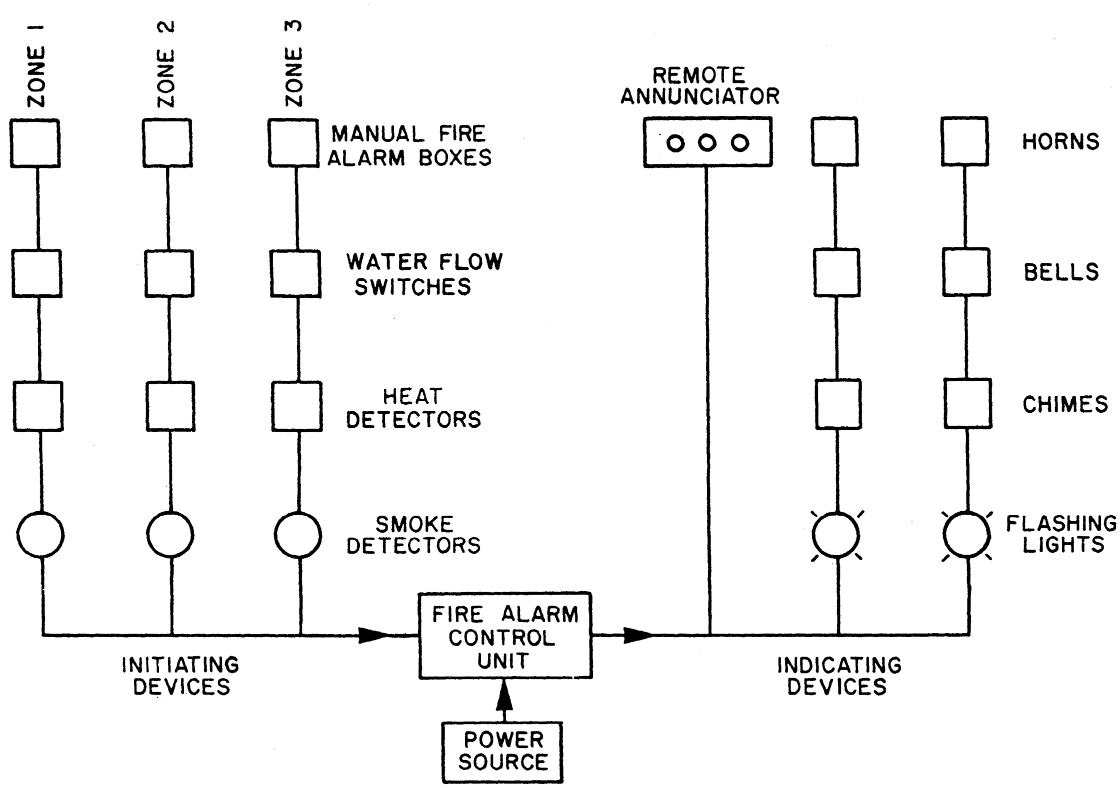

Figure 7-1.—Local fire alarm system diagram.

System Power Supply

Power supply refers to the circuitry and components used to convert the ac line voltage to low-voltage ac or dc for operating the alarm system and for charging standby batteries. If the system is an older one with a dry cell, nonrechargeable standby battery (no longer permitted by NFPA standards), the power supply probably contains a switching arrangement for connecting the battery to the system when ac power fails. Figure 7-2 is a simplified diagram of a typical dc power supply for powering a low-voltage dc alarm system and for charging a rechargeable standby battery.

Transformer T drops the line voltage from 120 volts ac to a voltage in the range of 12 to 48 volts ac. The low ac voltage is rectified by diode bridge D, and the resulting dc voltage powers the alarm system through relay contacts S1 and charges battery B through the current limiting resistor R. When normal ac power is available, energizing relay coil S, contacts S1 are closed. If ac power fails, S1 opens and S2 closes, connecting the battery to the alarm system. Fuse F1 protects against a defect in the power supply or the alarm system during normal ac operation. Fuse F2 protects against alarm circuit defects that would cause a battery overload during dc-powered operation. Removal of resistor R eliminates the battery-charging feature and allows the use of a dry cell battery, which sits idle until ac power fails. At that time, S1 opens and S2 closes, connecting the battery to the alarm system.

There are many variations of this basic power supply design. These variations add such features as voltage regulation, current limiting, and automatic high-rate/low-rate charging, controlled by the state of battery charge. All designs normally provide current and voltage meters, pilot lamps, and switches for manual control of charging rate.

Smoke Detector Power Supply

When smoke detectors are used in an alarm system, their internal electronic circuits are usually powered from the main fire alarm power supply.

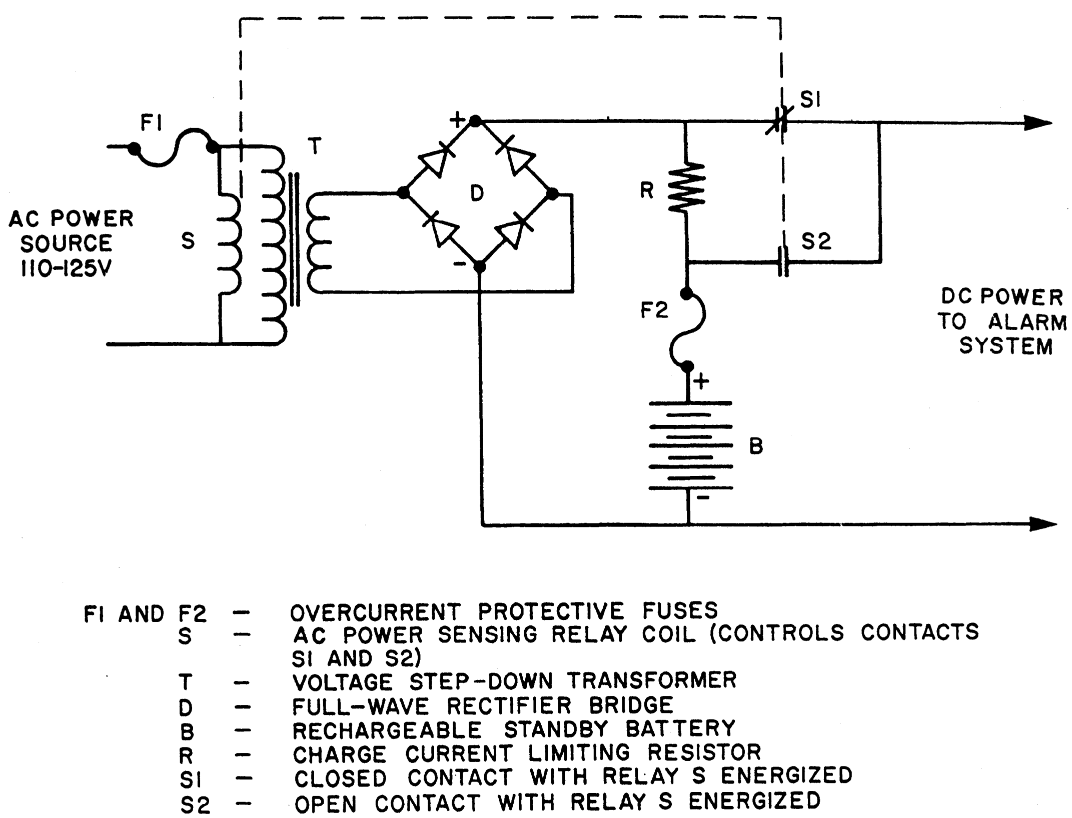

Figure 7-2.—Typical dc power supply and battery charger.

Some types of smoke detectors have a more strict power supply requirement than other parts of the fire alarm system, especially with regard to purity of the dc voltage level. The power supply of those smoke detectors must have output voltage regulation and filtering not otherwise required by the fire alarm system. In those cases, the basic power supply may be upgraded to power the smoke detectors as well as the control unit, or a separate smoke detector power supply may be used in addition to the basic supply. In either case, if the system has battery standby, it is usually common to both power supplies.

CONTROL UNIT

The fire alarm control unit provides termination points for all initiating circuits, indicating circuits, remote annunciators, and other auxiliary devices. The control unit accepts low current signals from the alarm-initiating circuits and, through relays or other circuitry, provides the larger current required to operate the alarm-indicating devices and/or auxiliary devices. The control unit also continuously monitors the condition of the alarm initiating and indicating circuit wiring and provides a trouble indication in the event of an abnormal condition in the system, such as an ac power failure or a wiring failure.

The control unit is usually housed in a sheet metal cabinet (fig. 7-3). The control unit usually provides annunciation of signals (telling where a signal originates).

Because all circuits end at the control unit, it is a convenient test location. Test switches (if provided) are usually inside the locked door of the control unit. If the switches are key operated, they may be on the control unit cover rather than inside the cabinet.

Local Alarm Signaling

Because of the critical nature of fire alarm systems, a feature known as "electrical supervision" has been designed into these systems. Alarm systems must be in service at all times; electrical supervision causes a warning (trouble) signal if some potential or actual electrical problem exists in the alarm system. This trouble signal is clearly distinguishable from a fire alarm signal. Figure 7-4 shows a typical local alarm signaling circuit using electrical supervision.

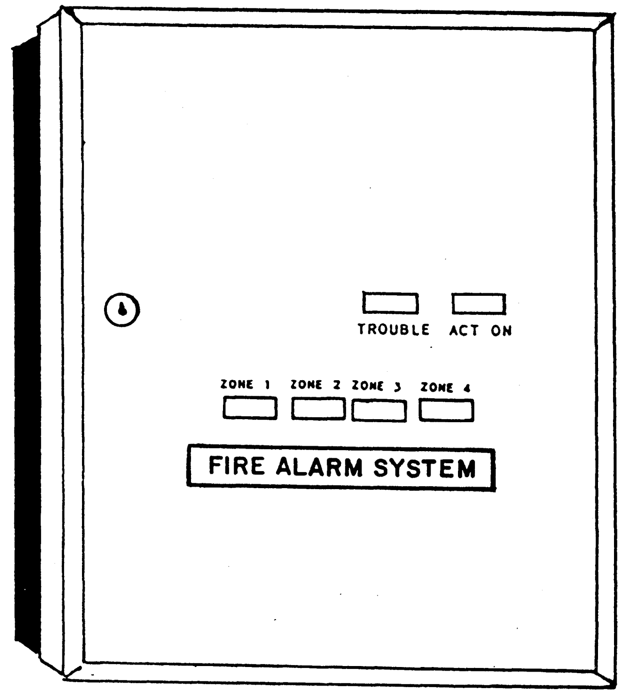

Figure 7-3.—Control unit with annunciation.

A continuous small electrical current, supplied by the fire alarm control panel, flows through the series loop formed by one side of the initiating circuit, the end-of-line resistor, and the other side of the initiating circuit as indicated by the arrow. The fire alarm control panel reacts to this constant low current as a no-alarm or normal condition.

Under normal conditions, the alarm and trouble relay coils have the same low value of supervisory current flow. This value is inadequate to close the normally open contacts of the alarm relay. The trouble relay, being more sensitive, is energized by the supervisory current, and the normally closed contacts (TR1) are held open. If the supervisory current drops to zero because of a broken wire anywhere in the initiating circuit, the trouble relay is de-energized, and the TR1 contacts close, causing an audible and visual trouble signal. Also, the portion of the circuit beyond the broken wire will not operate in the event of an alarm.

If no wires are broken, closing the contacts of an initiating device provides a low-resistance current path, short-circuiting the end-of-line resistor and increasing the alarm relay coil current. The alarm relay is energized, causing its contacts (AR1) to close and the alarm bells to ring. Continued fire alarm operation with a broken wire depends upon the location of the break and which initiating device is actuated.

Remote Alarm Signaling

Because of excitement, a lack of knowledge, or a lack or responsible personnel on the premises, people frequently do not react properly to a local fire alarm signal. Therefore, it is usually desirable to connect building alarm systems to a remote receiving station manned at all times by competent personnel who can take the proper action-to extinguish the fire and evacuate the building if necessary or to see that necessary maintenance is completed. Most fire alarm and supervisory alarm control panels have provision for connection to a remote receiving station. These connections are usually in the form of auxiliary relay contacts that can be connected to operate an alarm transmitter.

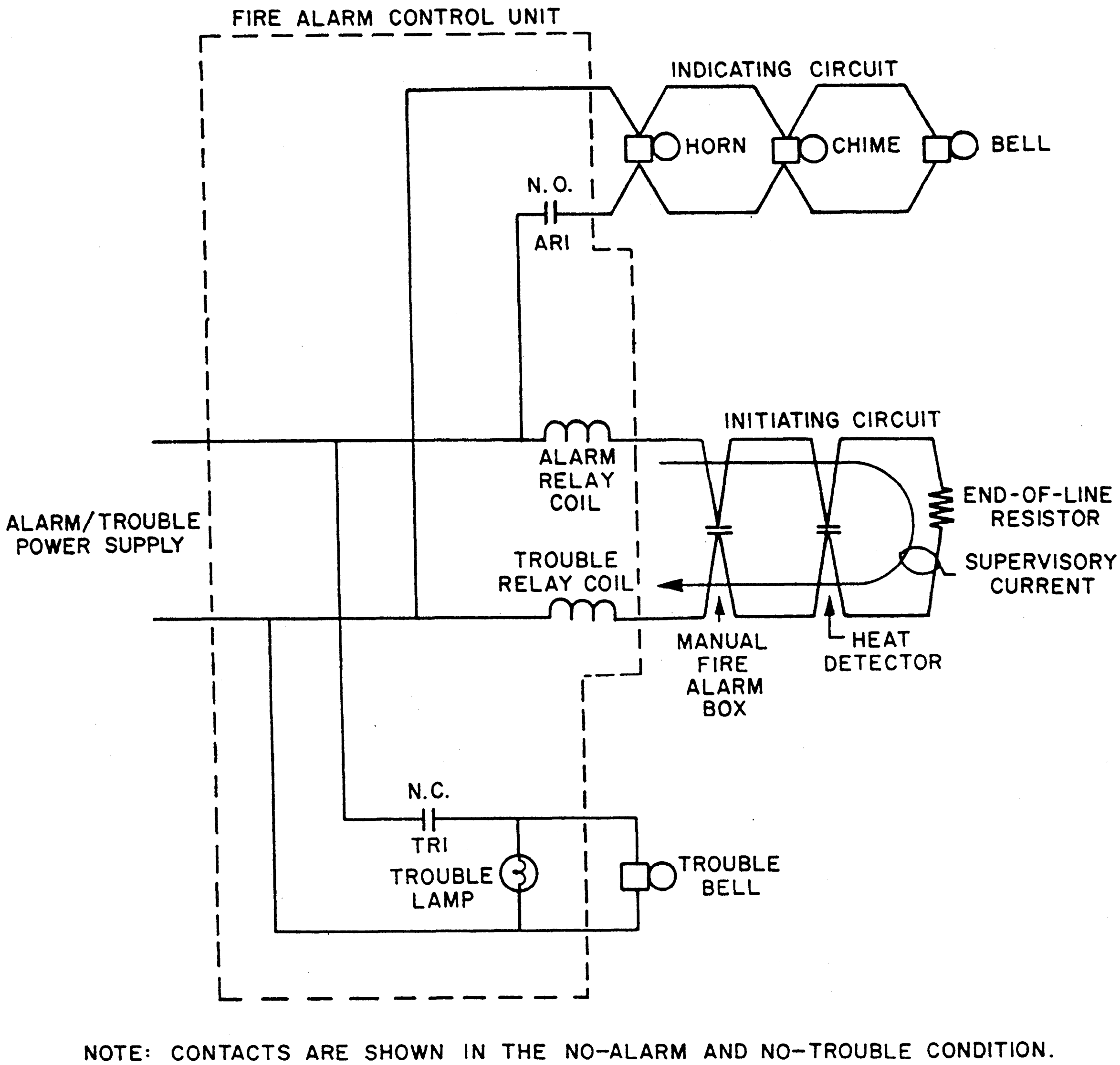

Figure 7-4.—Typical local alarm signaling circuit.

Figure 7-5 shows a typical remote alarm signaling circuit, a commonly used arrangement for fire department connection to individual building alarm systems. The alarm transmitter can either be a part of the fire alarm control cabinet or be operated by it.

If, instead of a fire condition occurring, one of the two telephone wires is broken, the supervising current supplied by the transmitter will drop to zero, closing the receiver module relay contacts, lighting the lamp, and sounding the buzzer. The meter indication will be zero, marked on the meter face as "T" (trouble).

If a telephone wire is broken before an alarm condition occurs, the voltage will be reversed by the alarm transmitter, but the "no current" condition at the alarm receiver will not be changed, and no alarm will be caused. The trouble condition will continue until the broken wire is repaired.

In the circuit shown in figure 7-5, if an alarm condition occurs, the transmitter contacts transfer, reversing voltage and current polarity of the telephone line pair. The meter in the receiver module changes indication from N (normal) to A (alarm). Current flow through the receiver module relay is blocked by diode D1, and the receiver module relay contacts close, lighting the lamp and sounding the buzzer. The current for meter alarm indication flows through the meter and diode D2.

Auxiliary Devices

A building alarm system control unit may have auxiliary contacts that operate auxiliary functions when an alarm occurs. For auxiliary devices, the power source can be either the main fire alarm power supply or line power, if battery standby power is not required for the auxiliary functions. A failure of auxiliary functions should not adversely affect the primary function of the alarm system, which is to warn the occupants of a threat of fire.

One auxiliary function included in the majority of fire alarm systems today is the heating, ventilation, and air conditioning (HVAC) fan shutdown. Auxiliary contacts are connected into the motor starter circuit for each fan that is to be shut down upon alarm.

It may be more convenient to use an alarm voltage output from the control unit to cause fan shutdown. A relay with multiple contacts (a multipole relay) for controlling multiple fans is located near the motor control center or the temperature control panel. The relay coil is energized by alarm voltage from the alarm control unit, causing contacts to open in the individual

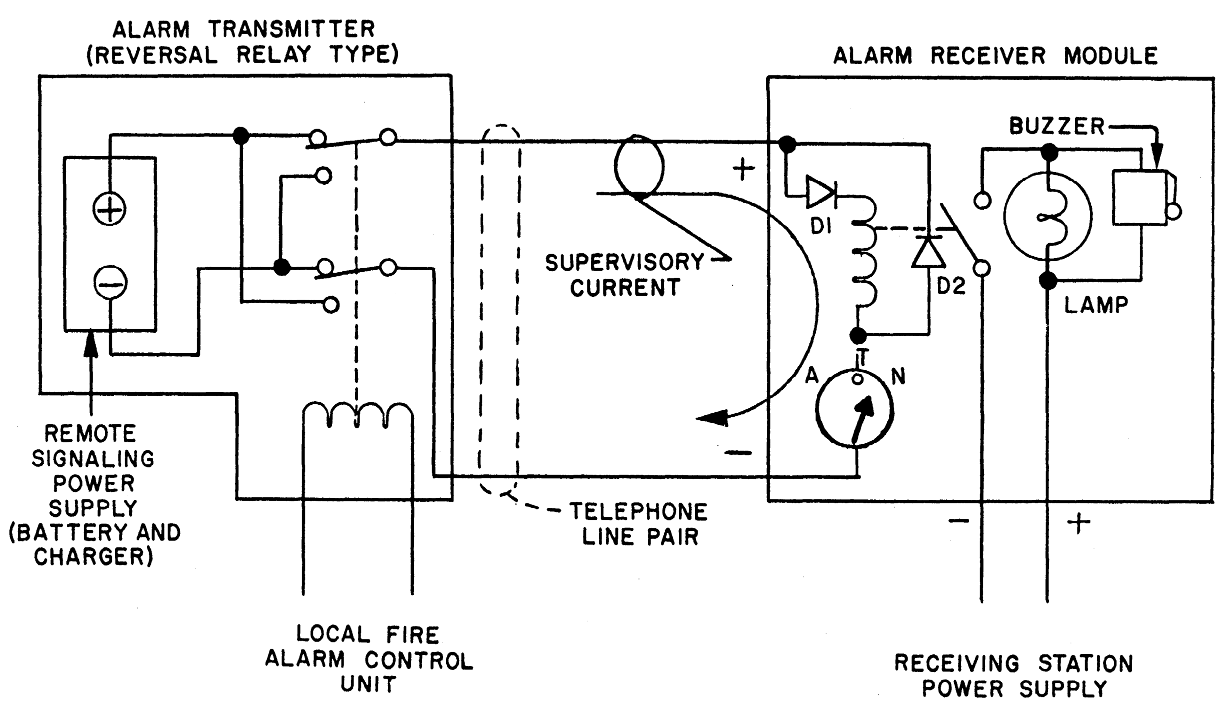

Figure 7-5.—Typical remote alarm signaling circuit.

fan control circuits, thereby stopping all the fans.

Other auxiliary devices controlled by the alarm system can perform the following functions: fire door closure, ventilation louver closure, and/or release of extinguishing agent. Consult the manufacturer's literature and/or base blueprints to determine the options included in your fire alarm system.

ALARM-INITIATING DEVICES

An alarm device initiates a fire alarm signal either as a result of manual operation, such as a manual fire alarm station, or automatically, as in the case of heat, smoke, flame, or water-flow detectors. Initiating devices, with rare exceptions, have normally open contacts that close on an alarm condition.

Normally closed devices are intended only for such applications as operating the shutdown control for fans or other auxiliary devices.

Manual Fire Station

Figure 7-6 shows a manual fire station, which is also called a manual pull box, a manual firebox,

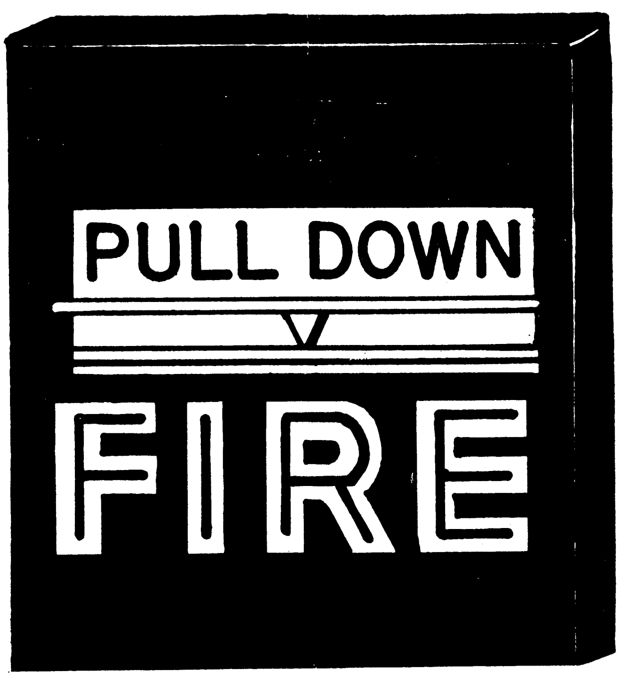

Figure 7-6.—Manual pull box.

or a manual fire alarm. A manual fire alarm system may include many initiating devices.

The manual fire alarm devices are to provide a means of manually activating the fire alarm system. They are used in all types of fire alarm systems. They may be the only type of initiating devices provided or they may be used with automatic initiating devices, such as heat or smoke detectors.

Manual fire stations are generally located near main exits from a building or from a floor of a multistory building and in certain work areas containing unusual fire hazards, valuable equipment, or records subject to fire damage. Paint shops, aircraft repair areas, computer rooms, and telephone equipment rooms are examples of such work areas.

Single-action and double-action devices are both used. The single-action device requires one action to cause an alarm, and a replaceable glass rod is broken with each operation. The double-action device requires two actions to cause an alarm: first, the glass window is broken; second, the alarm lever is pulled. The glass elements in these two examples are necessary parts to retain all the design features. Both devices can be tested without breaking the glass parts by opening the device. To open a manual fire alarm box, you may have to loosen a setscrew or operate a latch with a hexagonal (allen) wrench, screwdriver, or key.

Manual initiating devices should be visually inspected monthly for physical damage, such as that caused by vandalism or painting. At this time, count the devices to be sure that none have been concealed or removed. Correct deficiencies promptly. Test repaired units by mechanical operation and transmission of local and remote signals without glass breakage. Be sure to inform building and fire department personnel that the test is to be performed.

Test all manual devices on a rotation schedule so that all devices are tested semiannually. Some devices should be tested each month, at least one from each initiating circuit (zone) or remote signaling circuit, in the case of coded fire alarm boxes. Keep accurate records of devices tested, their locations, and the rotation scheme. Store a copy of building system diagrams and test records in the control unit.

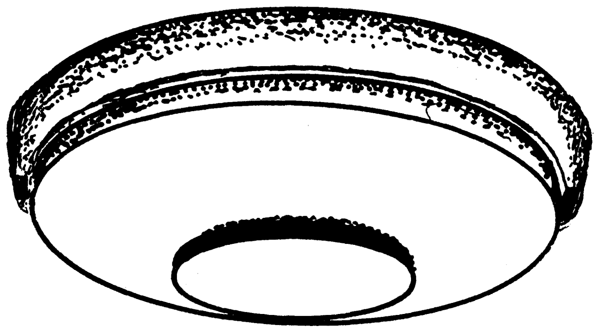

Figure 7-7.—Low-profile heat protector.

Heat Detectors

Heat detectors are probably the most widely used initiating device for general-purpose automatic fire alarm systems. Some common types of heat detectors are discussed below.

SPOT TYPE OF FIXED-TEMPERATURE DETECTORS.—Fixed-temperature heat detectors that are categorized as spot type have a detecting element or elements that respond to temperature conditions at a single point or in a small area.

These detectors are shown in figures 7-7 and 7-8. Other fixed-temperature detectors are manufactured in the style shown in figure 7-9. The spot type of fixed-temperature detectors is used mainly in unattended spaces to detect smoldering fires that increase the temperature of a detector above its design value, usually 135°F to 145°F or 185° to 200°F. The higher temperature devices are used in spaces that may reach higher temperatures under ordinary conditions, such as boiler rooms, attics, or cooking areas.

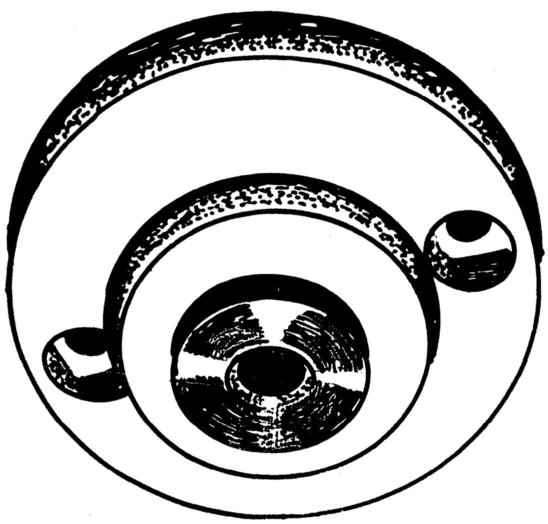

Figure 7-8.—Replaceable-element fixed-temperature heat detector.

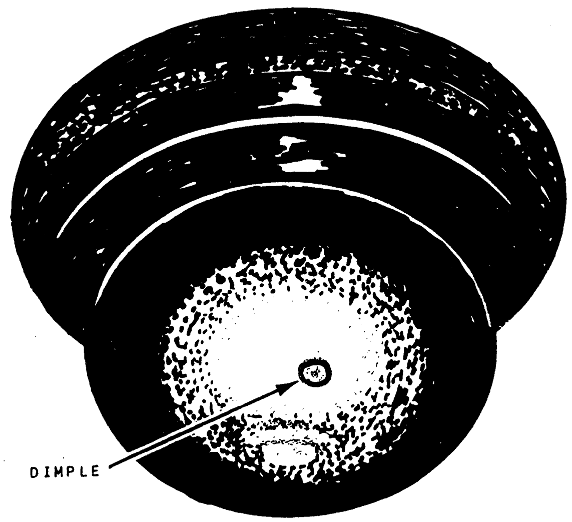

Figure 7-9.—Combination fixed-temperature/rate-of-rise heat detector.

The device usually is actuated by the melting or fusing of an element made of a fusible metal alloy. Actuated devices usually can be detected by visual examination.

In the devices shown in figures 7-7 and 7-8, the smaller diameter part in the center drops away. In figure 7-9, the dimple becomes a hole when the detector operates.

Fixed-temperature devices are often designed for one-time operation, and the whole device (figs. 7-7 and 7-9) or the element (fig. 7-8) needs to be replaced.

RATE-COMPENSATED DETECTORS.—This type of detector is shown in figure 7-10. For low rates of temperature change (up to 5°F per minute), rate-compensated detectors operate like fixed-temperature detectors. For higher rates of temperature change, the detector anticipates the rise in temperature to its set point and operates faster than the usual fixed-temperature detector. It automatically resets and is reusable when the

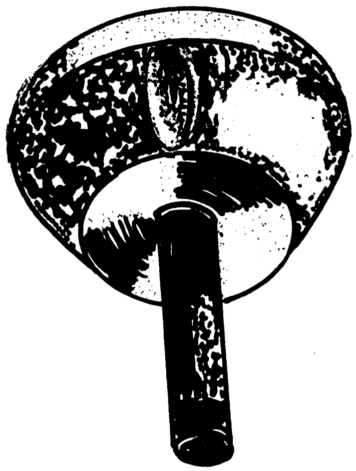

Figure 7-10.—Rate-compensated heat detector.

temperature drops below its design value. There is no difference in external appearance between an actuated device and an unactuated device; therefore, its status must be checked electrically.

RATE-OF-RISE DETECTORS.—These detectors are found in the styles shown in figures 7-7 and 7-9. Rate-of-rise detectors cause an alarm whenever the rate of temperature rise exceeds about 15°F per minute. Heating causes an increase in air pressure inside the detector. A slow increase in pressure bleeds off through a breather valve, while a fast increase operates a bellows type of diaphragm, which operates the alarm contact, causing a signal. The detectors automatically reset after actuation and are reusable. Actuation is not visually indicated.

COMBINATION DETECTORS.—These detectors are found in the styles of figures 7-7 and 7-9. The combination detectors contain both fixed-temperature and rate-of-rise elements. If either element actuates, an alarm results. The fixed-temperature element is visible and actuates only once. If the fixed-temperature element actuates, the whole device must be replaced. The rate-of-rise element automatically resets and is reusable.

TESTING HEAT DETECTORS.—Test heat detectors semiannually on a rotation schedule to ensure that all devices will be tested over a 5-year period. During the semiannual tests, select at least one detector from each initiating circuit (zone) for testing. Nonreusable detectors with replaceable elements can be tested by removing and reinstalling the element. Test and replace all nonreusable detectors in a 5-year period. The testing provides training opportunities and improves the alarm system reliability.

Keep accurate records of devices tested, their locations, and the rotation scheme so no devices are overlooked and so that other personnel can do the testing.

The spot type of heat-actuated detectors can be tested using various sources of heat. If the detector is located in a hazardous area that may contain explosive fumes or other highly flammable materials, use an explosionproof lamp. For nonhazardous areas, the heat source may be an infrared lamp, a hair dryer, or a hot-air gun. Be careful to avoid heat or smoke damage to reusable detectors and to the surroundings.

To test combination detectors that have a nonreuseable fixed-temperature element, test both the rate-of-rise and fixed-temperature features. First, use a higher heat level for a short period and direct it away from the fusible fixed-temperature element, if possible, to actuate only the rate-of-rise element. When an alarm occurs, allow cooling; reset; and then apply more gradual heat to actuate the fixed-temperature element.

Smoke Detectors

Smoke detectors are faster acting than heat detectors. They are frequently used in fast-acting automatic fire detection systems that incorporate an extinguishing agent release function to protect high value or highly combustible storage and work areas. Computer rooms, aircraft storage and repair areas, explosive processing areas, and telephone equipment rooms are frequently protected in this way.

Smoke-actuated detectors may be of the photoelectric type used in spot, beam, or duct designs or the ionization type, which is applied in the spot or duct design. The principle of operation is the same, regardless of design.

PHOTOELECTRIC SMOKE DETECTORS.—Most modern photoelectric detectors of the spot type use the light-reflection principle to detect

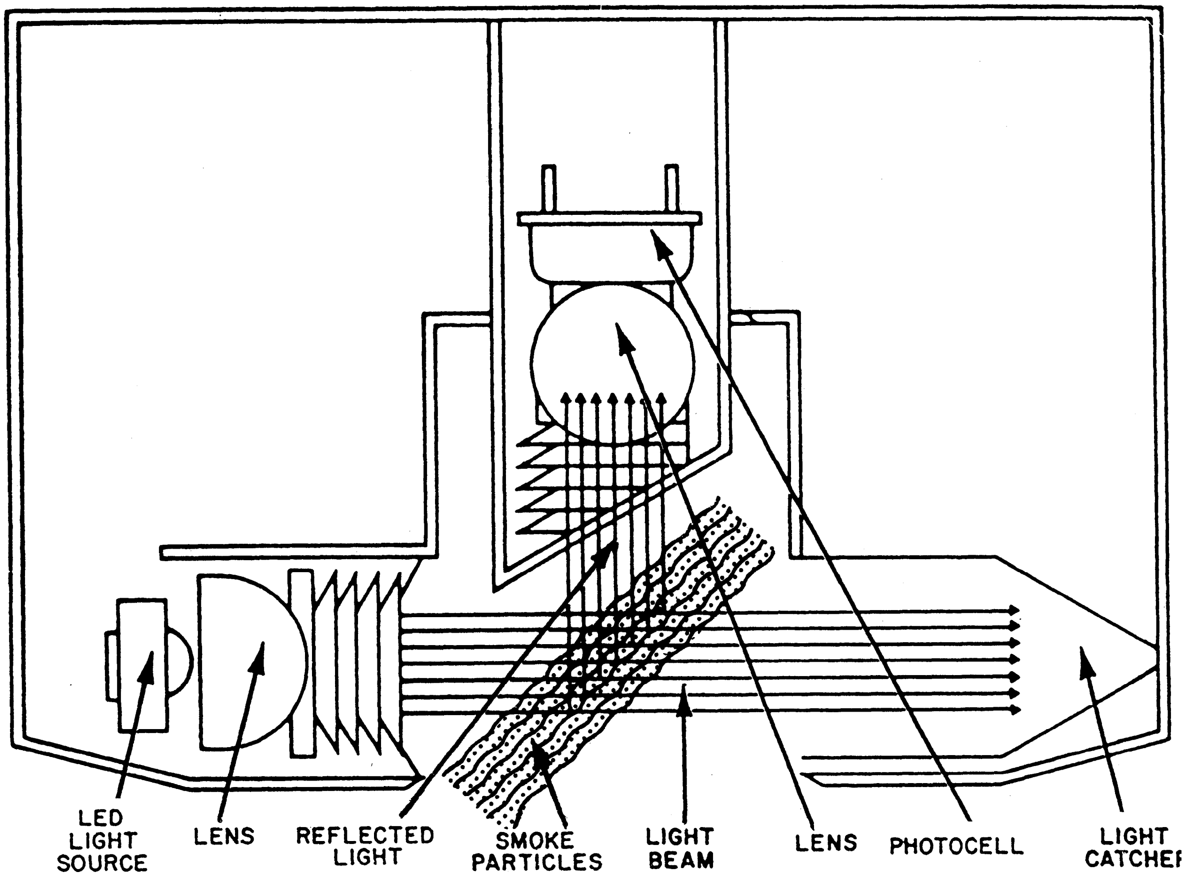

Figure 7-11.—Typical arrangement of photoelectric smoke detector components.

smoke. The diagram in figure 7-11 shows a typical arrangement of functional parts. A pulsed light beam from a light-emitting diode (LED) with its associated optics is projected across the interior of a blackened chamber that may contain smoke to be detected. A photocell, with its optics, looks toward the projected beam along a line perpendicular to the beam. When smoke enters the chamber, the smoke particles reflect a small portion of the light beam toward the photocell, which provides a voltage to be amplified and causes an alarm. The light source may be monitored ahead of the smoke chamber and regulated to prevent variation of the light intensity from causing erratic detector behavior.

In detectors of the beam type, the light source and photocell are mounted near the ceiling on opposite sides of the protected room. When smoke obscures the light below a predetermined value at the photocell, an alarm results.

Detectors of the duct type are intended for detecting smoke in an air-handling system. A detector of this type is mounted directly on the outside of an air duct or nearby with a sampling tube extending about three quarters of the way across the inside of the duct. The air flows into the smoke detection chamber mounted on the outside of the duct, and back into the duct through a return tube, having a hole or holes directed downstream. As long as there is airflow in the duct, a portion of that air continuously flows through the detection chamber.

IONIZATION SMOKE DETECTORS.—A small amount of radioactive material ionizes the air inside a chamber that is open to the ambient air. A measured, small electrical current is allowed to flow through the ionized air. The small, solid particle products of combustion that enter the chamber as a result of fire interfere with the normal movement of ions (current), and when the current drops low enough, an alarm results. A two-position switch to control sensitivity may be provided. A detector of this type is shown in figure 7-12.

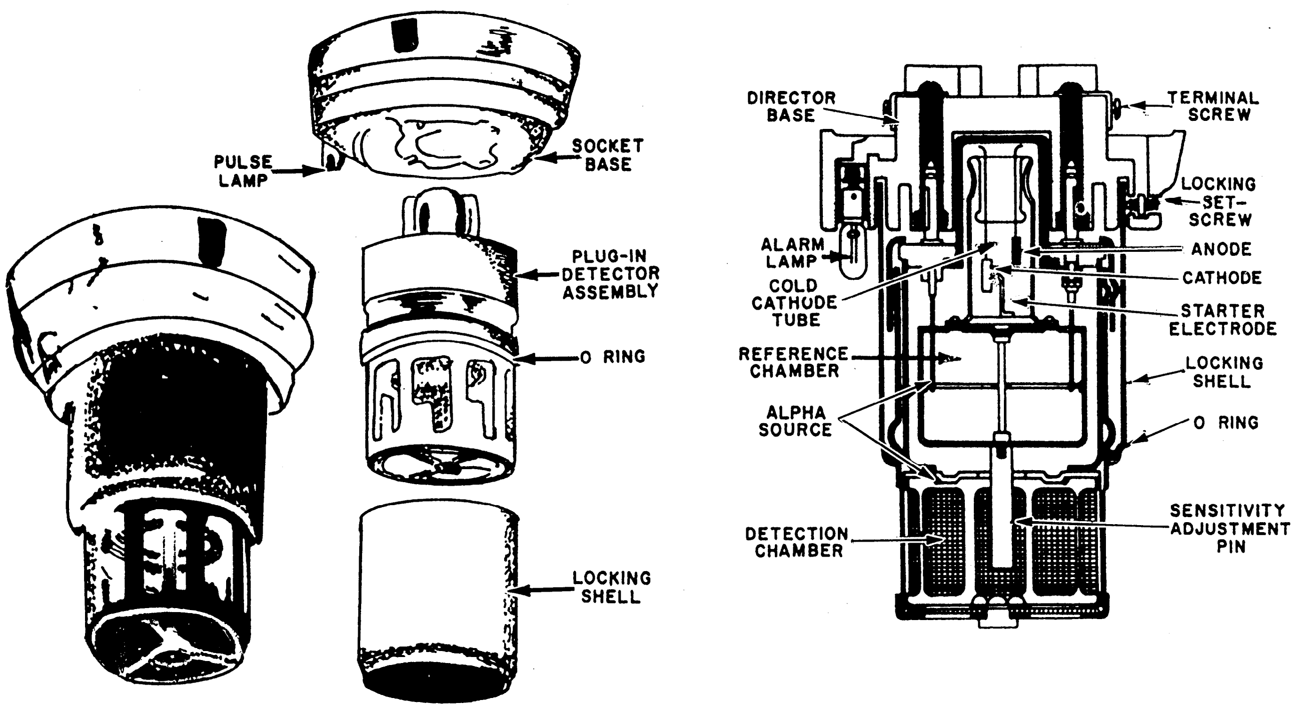

Figure 7-12.—Ionization Smoke detector.

Modern ionization detectors have additional means to improve stability and immunity to atmospheric effects. A reference chamber is vented to the outside through a small orifice, which does not readily admit smoke particles. Temperature, humidity, and pressure changes are sensed by both the reference chamber and the smoke chamber, and their effects on alarm sensitivity are eliminated by electronic balancing.

The major difference between detectors of the spot and duct types is the method of moving the smoke into the detection chamber. The spot type detects or relies on convection of air in a room. The duct type is intended. for detecting smoke in an air-handling system and is mounted directly on the outside of an air duct or nearby with sampling and return tubes extending completely across the duct.

TESTING SMOKE DETECTORS.—Before testing detectors that are connected to auxiliary functions, such as release of a fire extinguishing agent, release of fire doors, or fan shutdown, disconnect or bypass the auxiliary functions (unless the test is specifically intended to test these features). Before the test, notify the fire department and persons where the audible signals can be heard.

Most PHOTOELECTRIC detectors have a built-in test feature. In some models, a test light source actuated by a key-operated test switch or by a magnet held near a built-in reed switch causes light to reach the normally dark, smoke-sensing photocell in a quantity approximately the light of an average smoke test. In other detector models, the smoke simulation is performed by inserting a reflective surface into the smoke chamber so that the actual source light is reflected to the smoke-sensing photocell. Test at least one detector in each initiating circuit (zone) monthly. Follow a rotation schedule so that all detectors are tested semiannually.

Test failures or false alarms may result from an excessive accumulation of dust or dirt caused by an adverse environment. Blow out the smoke chambers with low-pressure air. (Partial disassembly of the detectors and disconnection of detectors' power, following the manufacturer's instructions, are required.) Since the photocell is normally dark, disassemble and clean it in a darkened area to minimize the photocell recovery time after cleaning before repowering the detectors. Allow approximately 30 minutes for recovery after reassembly of the detectors before reconnecting power.

Disconnecting power by unplugging one detector may also disconnect power from the other detectors further from the power source. Inform the fire department before or during any extended testing period.

Special equipment that may be required for cleaning consists of a low-pressure air source for blowing out dust and a suction cup for chamber cover removal.

If the cleaning does not correct the false alarms or failure to alarm, return the detectors to the manufacturer for repair.

Test at least one IONIZATION detector in each initiating circuit (zone) monthly. Follow a rotation schedule so that all ionization detectors are tested semiannually, following the manufacturer's instructions. Any detectors that produce false alarms between semiannual tests or do not test satisfactorily should be checked for sensitivity, following the manufacturer's instructions and using test equipment available from the manufacturer or other sources. An aerosol synthetic smoke is available from some manufacturers for testing their detectors.

Unsatisfactory tests or erratic operation may indicate a need to remove accumulated dust or dirt. The frequency of cleaning should be based on results of regular tests and local conditions. Clean, check, and test operation and sensitivity, following the manufacturer's instructions. For loose dust deposits, blow the area with low-pressure air after removing a protective cover. For more stubborn deposits, disassemble and clean, using a liquid recommended by the manufacturer. Recheck sensitivity and adjust if necessary after cleaning and drying thoroughly.

WARNING

Some smoke detectors of this type produce an electrical shock that may not be severe enough to cause injury directly but could cause a fall from a ladder. Some manufacturers, because of such possible injury to personnel or damage to the detectors, do not recommend servicing by anyone other than factory-trained personnel. Personnel in the customer service departments of most manufacturers can give advice on the telephone for specific problems. Be prepared to give the equipment model number and other pertinent information.

Flame-Actuated Detectors

Flame-actuated detectors are optical devices that "look at" the protected area. They generally react faster to a fire than nonoptical devices do.

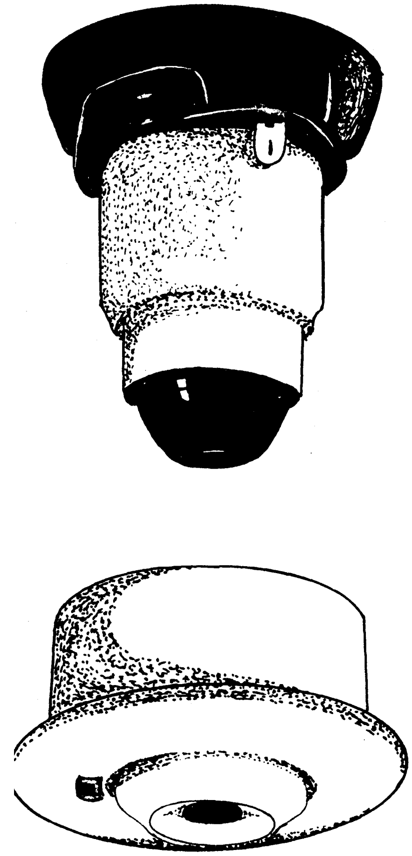

Figure 7-13.—Infrared flame detectors.

INFRARED FLAME DETECTORS.— Figure 7-13 shows two typical infrared (IR) flame detectors. IR flame detectors respond directly to the IR, modulated (flickering at 5 to 30 cycles per second) radiation from flames. The sensor design usually incorporates a delayed response, selectable in the range of 3 to 30 seconds, to minimize responses to nonfire sources of radiation. Thus, alarms are caused only by sustained, flickering source of IR radiation.

The IR flame detector is ineffective for smoldering or beginning fires. It is used where possible fires would develop quickly (fuels, such as combustible gases and liquids, or loose cotton fiber), and it is capable of protecting a large area if it is mounted high on a ceiling or wall (30 to 50 feet).

The sensitivity of IR detectors to a fire is affected by the distance of the device from the fire. For example, if the distance is doubled, the fire has to be four times as large to be detected. To maintain immunity to possible nonfire sources of alarms, you should usually select longer response delays (10 to 30 seconds) for low (8-foot) ceiling mounting. Shorter delays, in the range of 3 to 10 seconds, are used when detectors are mounted on higher ceilings. For high-hazard areas, the detector can be mounted on a low ceiling and a low delay setting used to obtain sensitivity and fast response. Shields to eliminate possible false alarm sources from the field of view of the detector are sometimes used, especially in a high-sensitivity application of the device.

Some detector models designed for fast response do not have the "flicker" discrimination feature, but instead have two sensors with different spectral responses. These sensors are used to distinguish between an actual fire and other sources of IR radiation.

Glowing ember detectors are nondiscriminating and fast acting. Ambient light levels must be maintained below 20 footcandles. Location and shielding are important for this type to avoid false alarms caused by incandescent lamps and sunlight.

ULTRAVIOLET FLAME DETECTORS.— The ultraviolet (UV) flame detector is extremely fast and is used in high-hazard applications, such as aircraft maintenance areas, munitions production, and other areas where flammable or explosive liquids or solids are handled or stored. The detector responds to UV radiation not visible to humans. Figure 7-14 shows a typical UV detector. The detector and circuitry may be in a single housing or in separate housings. They act

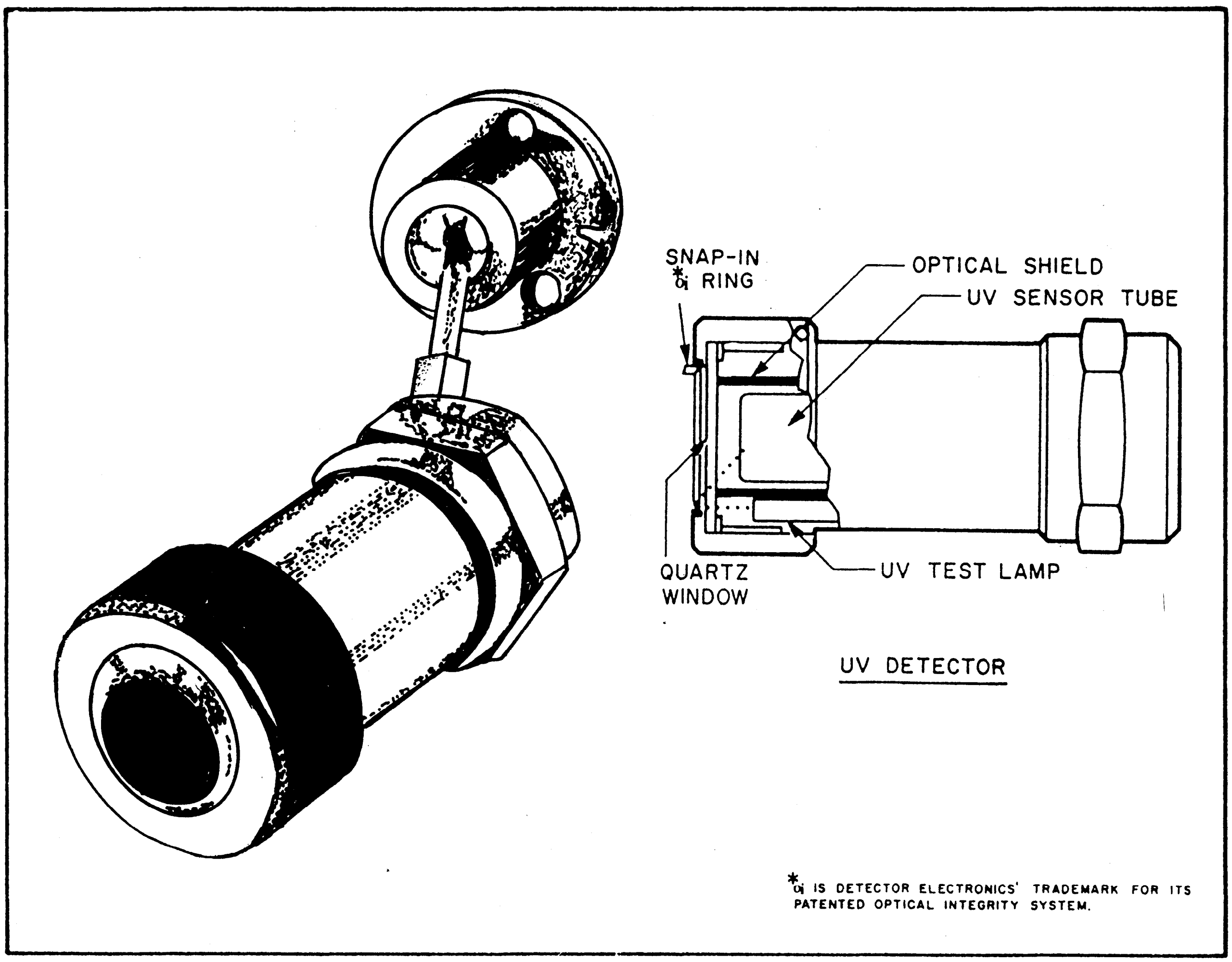

Figure 7-14.—Ultraviolet flame detector.

together as a normally open switch that becomes momentarily closed, causing an alarm, when UV radiation enters the detector viewing window. Response time is typically less than 25 milliseconds for an intense UV source. Some models have a built-in short time delay (3 seconds, nominal) to reduce responses to lightning and other momentary events.

Frequently, separate relay contacts are provided for immediate and delayed alarm outputs, adjustable up to 30 seconds. A visual indicator, visible through the viewing window, usually indicates detector actuation.

The UV detector is capable of use in explosive atmospheres, and some models have swivel mounts for directing them at specific hazards. Various models have angular fields of view ranging from 90 to 180 degrees. Sensitivity is usually factory set for the application.

TESTING FLAME-ACTUATED DETECTORS.—Flame-actuated detectors should be inspected monthly for physical damage, accumulation of lens deposits, and paint. A spot of paint on a lens can prevent the detector from "seeing" a critical area in the protected space. Remove or protect the detectors when painting is being done.

Be sure that auxiliary functions of the flame detection system are deactivated before testing is done unless these features are intentionally being tested. Before the test, inform the fire department and persons who would hear the alarm.

False alarms or failure to detect during a test may be caused by environmental factors or the aiming of the detector. During the monthly inspection, check that detectors are not blocked and that lenses are shielded from direct rays of the sun and other sources of IR, such as welding equipment, in the case of UV detectors.

If a detector has a clean lens but fails an operating test, make adjustments and/or perform other field maintenance, following the manufacturer's instructions. Obtain field service by a factory-trained technician or return the equipment to the manufacturer for repair.

Infrared Detectors.—On IR detectors (fig. 7-13), the dark spot or dome at the bottom center of each IR device is the lens. Detector lenses must be kept clean to ensure the earliest possible detection of a fire. Test at least one detector in each initiating circuit (zone) monthly. Follow a rotation schedule so that all detectors are tested semiannually.

A small soldering iron held 6 inches in front of a glowing ember detector can serve as a heat source for testing. A 250-watt IR heat lamp several feet from the detector can serve as a flame substitute in testing an IR flame detector.

Ultraviolet Detectors.—Keep UV detector lenses totally clean. A gradual buildup of contaminants frequently found in high-hazard spaces (oil, gasoline, petrochemicals, salt, and dust) block UV radiation. A layer thin enough to be undetectable to the human eye can cause a UV detector to be completely blind. Clean lenses according to the manufacturer's instructions.

A test feature designed into some detectors allows for checking the optical integrity of the device. A small UV source inside the detector housing is shielded from directly illuminating the sensor. Local or remote operation of a test switch deactivates alarm circuits and illuminates the test lamp. The test lamp rays then pass through the front window to the sensor. Detector response to the test indicates that the window is clean and that the sensor and electronic circuits are operational.

Water-Flow-Actuated Detectors

Sprinkler water-flow alarm-initiating devices are switches, just as fire alarm initiating devices are. Normally open switches that close upon alarm are frequently used in end-of-line resistor circuits, though some normally closed switches are used in normally closed loop circuits. However, the alarm-initiating devices for sprinkler water-flow mount differently and sense different conditions from fire-alarm-initiating devices.

Sprinkler water-flow detectors are generally pressure actuated or vane actuated. Pressure switches are used on both wet- and dry-pipe sprinkler systems. Vane switches are widely used on wet-pipe sprinkler systems.

PRESSURE TYPE OF WATER-FLOW DETECTORS.—Numerous styles of water-flow pressure switches of the pressure-increase type are found in wet- and dry-pipe systems. (Figure 7-15 shows one style.) The usual arrangement for switch actuation includes a sealed accordionlike bellows that is assembled to a spring and linkage. The spring compression or tension controls the pressure setting of the switch and may be adjustable and/or factory set to the desired pressure. As water or air pressure in the bellows increases, it expands, providing motion against a spring. The linkage converts the motion of the

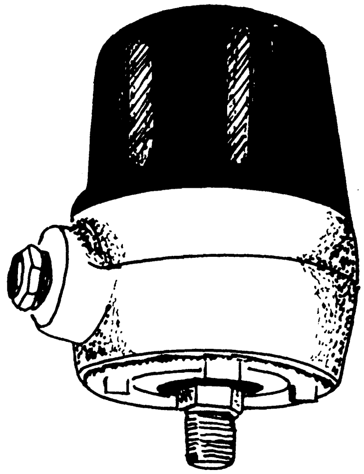

Figure 7-15.—Pressure-increase type of water-flow detector.

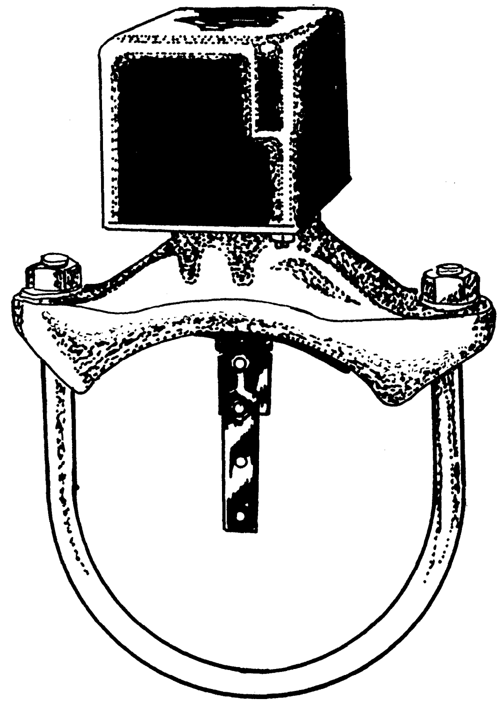

Figure 7-16.—Vane type of water-flow detector.

bellows into the desired motion to actuate the electrical switch. If the pressure switch is used on a wet-pipe system, it is usually mounted at the top of a retarding chamber, which reduces the speed of pressure buildup at the switch.

There are also water-flow pressure-increase detectors that incorporate a pneumatic retarding mechanism within the detector housing. The retard time is adjustable to a maximum of 90 seconds with usual settings in the 20- to 70-second range. The retarded switch would be connected to the alarm port of a wet sprinkler system alarm check valve. The usual pressure settings for these switches are in the range of 8 to 15 psi.

Pressure-drop detectors can be used in wet-pipe sprinkler systems equipped with a check valve that holds excessive pressure on the system side of the check valve. These detectors are most frequently used where a water surge or hammer causes false alarms with other types of water-flow detectors.

The construction of pressure-drop detectors is similar to that for pressure-increase detectors. The switch for a pressure-drop detector is arranged to actuate on a drop in pressure, and there is no retarding mechanism or chamber. A typical switch of this type would be adjusted for some normal operating pressure in the 50- to 130-psi range. The alarm pressure would be adjustable to 10 to 20 psi below the normal pressure.

VANE TYPE OF WATER-FLOW DETECTOR.—A vane type of water-flow detector, used only in wet-pipe sprinkler systems, is shown in figure 7-16. The vane (a flexible, almost flat, disk) is made of corrosion-resistant material. The detector is assembled to the pipe by drilling a hole in the wall of the sprinkler pipe. The vane is rolled up to form a tube and inserted into the pipe through the hole. Once inside the pipe, the vane springs open, almost covering the inside cross section of the pipe. The whole detector assembly is clamped to the pipe with one or two U-bolts. Gaskets and other sealing devices prevent leakage of water out of the riser pipe and into the detector housing. Operation of a sprinkler causes water to flow in the system, moving the vane. A mechanical linkage connects the vane to an adjustable retarding device in the detector.

The retarding device, which is usually a pneumatic dashpot, actuates the alarm switch or switches and/or signal transmitter if the vane is still deflected at the end of the adjustable delay period. The retarding device prevents spurious alarms by delaying the mechanical actuation of the alarm switch(es) and/or transmitter to allow the vane and retarding mechanism to return to their normal positions after momentary water surges. The retarding-device setting is usually in the range of 30 to 45 seconds, though the maximum setting may be as high as 90 seconds.

TESTING WATER-FLOW-ACTUATED DETECTORS.—Water-flow-actuated detectors should be inspected monthly for physical damage and for paint on information plates and labels. Replace or repair damaged devices immediately. Clean or replace painted plates and labels. Correct other deficiencies promptly.

Test wet-pipe-sprinkler-system-water-flow devices by causing a flow of water equal to that from one sprinkler by opening the inspector's test valve fully. This valve is usually near the end of the sprinkler system on the opposite side of the building from the system riser. For sectional water-flow detectors, the inspector's test valve is usually on the opposite side of the section of the building from the riser. The inspector's test valve is left open to allow full flow until an alarm is indicated at the local control unit or, if the control unit is connected to the base alarm system, until a clear alarm is received at the alarm headquarters. One person with radio or telephone communications at the test valve and one person at each alarm-receiving location are usually needed for testing.

The delay between the start of full flow and receipt of the alarm signal should be between 15 to 90 seconds for retarded signals. Detectors that sense a pressure drop should respond in less than 15 seconds. If the alarm has not been received after water has been flowing for 3 minutes, stop the test and determine the cause of the problem.

Dry-pipe sprinkler systems have an alarm test valve at the sprinkler riser in the trim piping that allows water from the supply side of the dry-pipe valve to exert supply pressure on a water-flow detector of the pressure-increase type. The alarm test valve is frequently a small lever valve but may be a globe valve. It should be permanently tagged Alarm Test Valve to expedite future testing.

The regular trip test of a dry-pipe sprinkler system to check the operating condition of the sprinkler system can also be used to test the water-flow detector and alarm system if the tests are coordinated. However, it is not practical to trip-test the dry-pipe valve for every alarm system test. Do not open the inspector's valve at the end of a dry-pipe sprinkler system for an alarm system test unless a trip test is desired.

The purpose of these initiating devices is to detect a fire condition and provide that information to the control unit. The control unit energizes the indicating circuit to warn building personnel for evacuation and to inform fire personnel of a fire.

ALARM-INDICATING DEVICES

Alarm-indicating devices are the lights or sounding devices that indicate a fire alarm or abnormal condition. These lights and sounds may also provide information about where the signal originates.

Indicating devices are divided into two major categories: visual (annunciators) and audible (bells, horns, chimes, and so forth).

Annunciators

Annunciators give a visual indication of the "zone" or general area where an alarm originated. In some cases, such as a sprinkler water-flow alarm, the annunciator can be arranged to identify the individual initiating device. In other cases, such as heat detectors, many initiating devices can activate the same indicator on the annunciator.

The annunciator indicator can be operated directly by auxiliary contacts in the initiating device or from a connection to the fire alarm control unit. A trouble or maintenance condition in the system wiring is also frequently annunciated by zone. Usually, a yellow or amber light indicates trouble and a red light indicates an alarm signal.

An annunciator may be incorporated into the fire alarm control unit, in which case it is generally actuated by connection to the control unit. It may also be located at a remote point, in which case it may be actuated either by the control unit or by auxiliary contacts in the initiating devices. Some installations may have a fire alarm control unit with an integral zone annunciator and a remote annunciator provided elsewhere. Frequently, the control unit standby battery is used to provide power for annunciator operation during power failure.

Annunciator visual indicators may be of the drop type or the lamp type. Those of the drop type (which are essentially obsolete) use electromagnetic devices to move a flag into or away from a window to indicate a change in zone condition. Annunciators of the lamp type use pilot light assemblies to indicate an alarm or trouble condition (usually red for alarm, amber for trouble). The more common type of annunciator in use today is the lamp type. Figure 7-17 shows a frequently used incandescent lamp annunciator.

More recent annunciator designs use matrices or arrays of light-emitting diodes (LEDs). The advantages of LEDs are low current, long life, and small size, allowing annunciation of many zones in a small space.

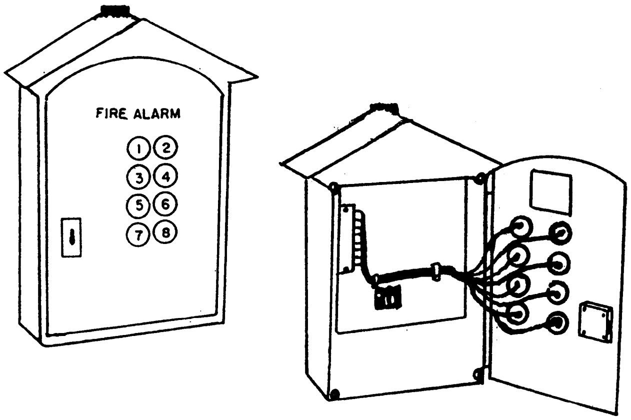

Figure 7-17.—Remote annunciator (weatherproof)

Audible Signal Devices

Any device that sounds an audible signal is classified as an audible signal appliance. The audible signal appliances most frequently used in building alarm systems are bells and horns. In addition, there are chimes, cowbells, buzzers, sirens, speakers, air horns, and steam whistles. Audible signals can be used to indicate either a fire alarm or a system-malfunction (trouble) condition. The audible signal appliances are connected to audible signal circuits for alarm or trouble indication (depending on their function) at the control unit. Figure 7-18 shows some of the commonly used audible signal appliances.

Audible signal appliances have varying levels of sound output. Louder devices are for areas with high ambient sound levels or where the devices cannot be located near the area to be warned. Hospitals might use softer devices, such as chimes, to avoid frightening patients.

Coded building alarm systems normally use single-stroke versions of bells or chimes so the coded signal can be clearly produced. Vibratory bells, chimes, or horns are used for noncoded systems but can also be used in coded systems if the mechanism used can respond rapidly enough to provide an accurate rendition of the code being transmitted.

In a building that uses audible signals routinely, such as bells for announcing class periods in school, the fire alarm audible appliances must have a distinct, easily identified sound. If the fire alarm signal is coded, the coding provides the distinctive sound, and it is feasible (though not normal) to use the same bells for both functions. For a non-coded fire alarm system, necessary distinction of sound can be obtained by using a completely different type of audible signal appliance, such as a horn or siren, for sounding fire alarm signals.

Testing Alarm-Indicating Devices

Test alarm-indicating devices monthly with the monthly inspection. When convenient, the test may be combined with a fire drill. Test by operating the drill switch or the test switch at the control unit or by actuating an initiating device. If the test switch or an initiating device is used, notify the remote alarm headquarters because remote signal transmitters

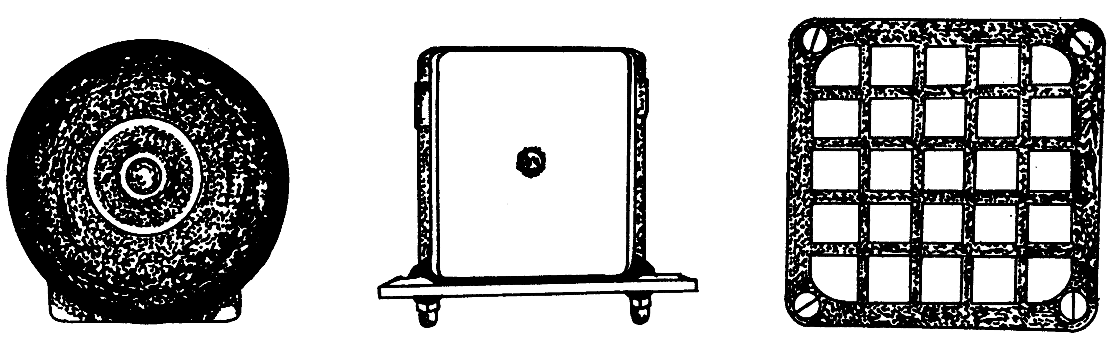

Figure 7-18.—Audible signal appliances.

and other auxiliary features will be actuated by such a test.

While there is an alarm condition, check all the indicating devices and note any that fail to operate properly. Audible devices should produce loud, clear, consistent tones, and coded system codes should be clearly recognizable. Visual devices should be bright and steady or pulsating, as intended.

Test annunciator lamps by operating a "lamp test" switch if it is provided; otherwise, cause an alarm and a trouble condition on each zone. It is usually convenient to cause these conditions at the control unit initiating circuit terminals.

When a single indicating' device fails to operate, it is usually defective. If a group of devices fails to operate, the fault is usually a defective circuit.

TROUBLESHOOTING CIRCUIT FAULTS

Because of the variations in equipment from manufacturer to manufacturer and the numerous types of circuits and devices in use, it is important to have the following reference materials available to personnel responsible for servicing:

- Wiring and Equipment Schematic Diagrams.

Complete, accurate wiring diagrams of each type of device in use, of each circuit as installed, and equipment schematic diagrams.

- Manufacturers' Data Sheets.

The descriptive information in manufacturers' data sheets on all equipment in use and

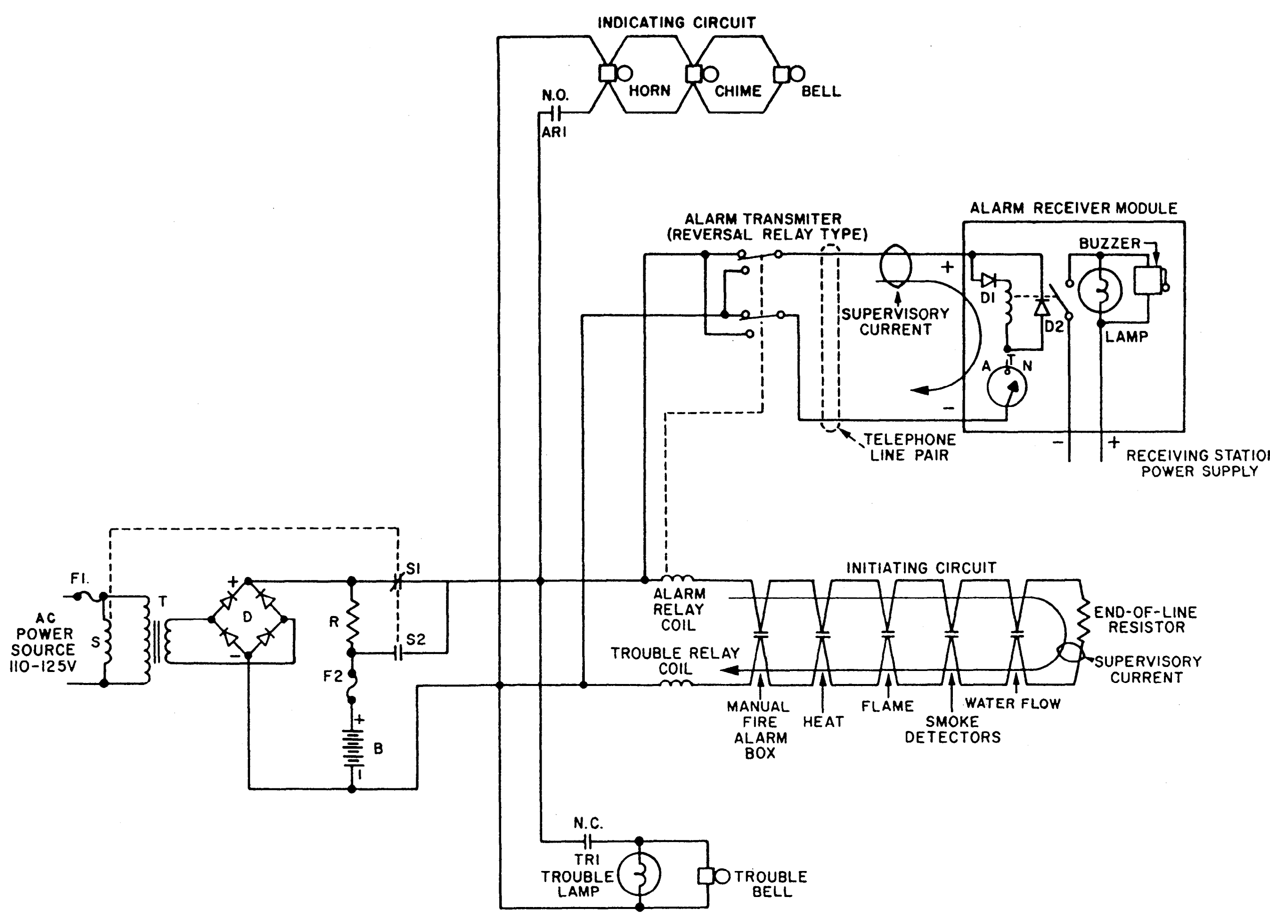

Figure 7-19.—Typical fire alarm system schematic diagram.

manufacturers' instructions for any special testing and maintenance.

- System Revision Information.

Information on all extensions or modifications to existing fire alarm systems.

- Tags.

Identification of wires removed from terminals during repair or testing is essential to ensure accurate reconnection. Improperly connected wires may make a fire alarm device or circuit ineffective or may actually damage equipment.

In general, detectors are returned to the manufacturer as a complete package for repair. However, control units and annunciators are large and interconnected with a number of other system components, and there should be some attempt at local repair before you ship the total unit to the manufacturer.

Circuit faults may occur in the connection to the power source, in the alarm-initiating circuits, and in the alarm-indicating circuits. Procedures for locating the fault depend on which one of these is involved. Figure 7-19 represents a typical building fire alarm system.

POWER SUPPLY CIRCUIT FAULTS

The common components in low-voltage control units that may require occasional replacement or maintenance are relays, resistors, capacitors, diodes, transformers, fuses, switches, lamps or LEDs, meters, and wiring. In addition, a modular control unit has replaceable modules. The modules plug into the main control unit assembly. The modules vary in construction but usually contain solid-state devices mounted on one or more printed circuit boards (PCBs). Sometimes the modules are sealed, but more often they can be disassembled for repair. Each module may represent one zone or a group of zones, or it may perform a nonzoned function, such as one of the following:

- Providing a time delay (such as shutting off bells after 15 minutes)
- Providing output contacts for a remote auxiliary function (such as fan shutdown)
- Transferring power (from commercial power to standby power and back)
- Sounding a local trouble buzzer
- Controlling audible signal devices
- Providing a reverse polarity alarm output (for remote station connection)

Use the manufacturer's diagrams and servicing information to narrow down any problems to a small area. If a problem can be isolated to one of these modules or if a problem appears to be related to a zone module, the most immediate repair is to replace the module. If the module is not sealed, inspect it for a condition such as an overheated resistor or transistor, a poorly soldered connection, a bent connector pin, or a malfunctioning relay. Repair or replace the parts, resolder the connection, or straighten the connector pin. For other conditions more difficult to analyze, replace the module. (Keep spares on hand.)

CAUTION

Any soldering that is performed, especially in replacement of solid-state devices on printed circuit boards, must be performed with care, following good commercial soldering practice.

Grounded and Short Circuits

A ground fault in the power source wiring will typically cause the building circuit breaker for the fire alarm system to trip. The equipment will continue to operate on standby battery, if one is provided. If the battery is discharged or if no battery is provided, the equipment affected will be out of service, and fire alarm protection will be nonexistent. Because battery capacity is limited and complete discharge should be avoided to prevent permanent damage to the battery, repair the fault immediately.

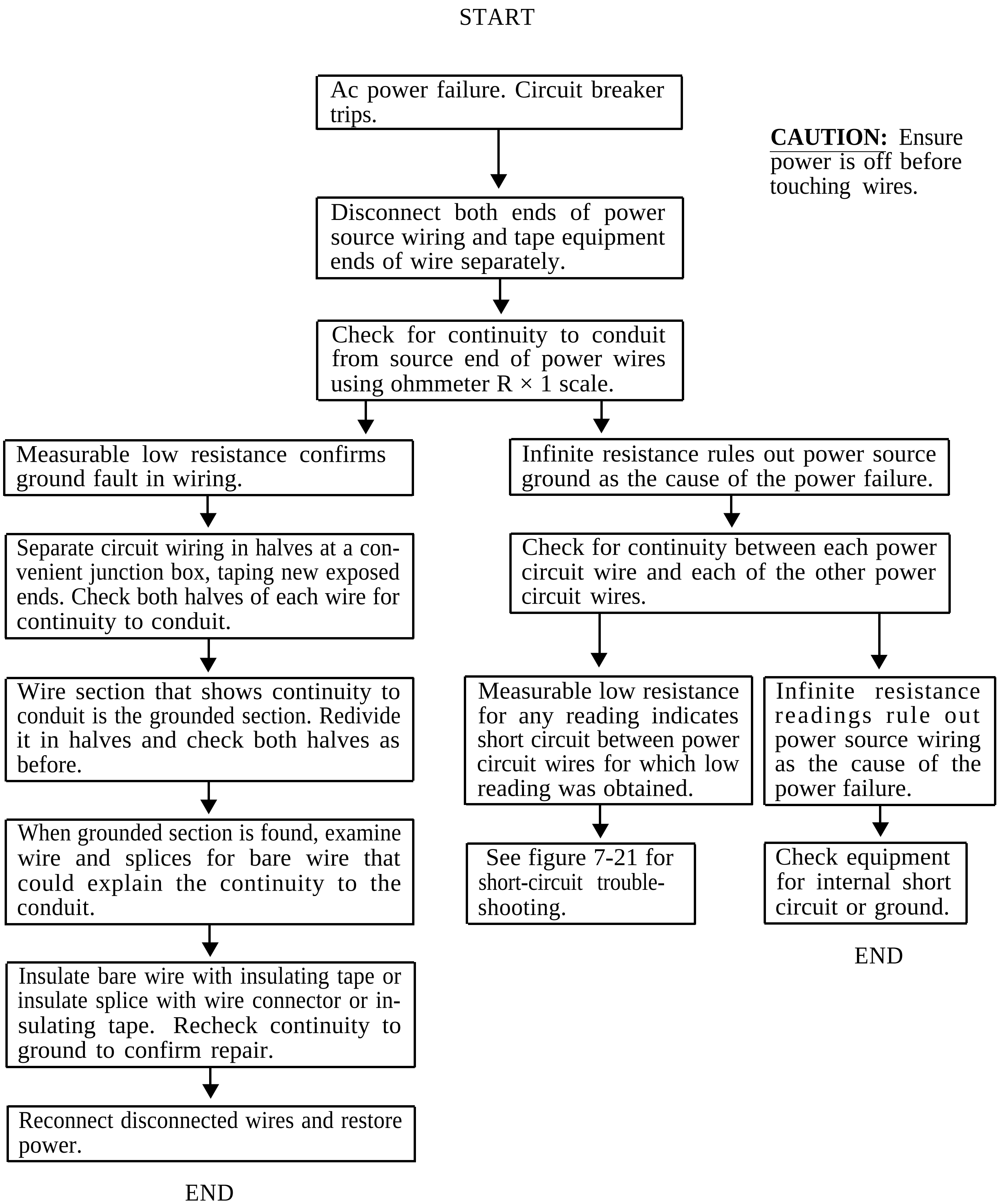

Figure 7-20.—Troubleshooting chart for a power circuit ground fault.

START

CAUTION: Ensure power is off before touching wires.

Continuity between power circuit wires indicates short circuit.

↓

Separate circuit wiring in halves at a convenient junction box, taping new exposed ends. Check both halves for wire-to-wire continuity.

↓

Section of wiring that shows continuity between wires is the short circuited section. Redivide it in halves and check both halves as before.

↓

Continue dividing in halves until short circuited section is found. Examine wires and splices for bare adjacent wires, which could explain the short circuit.

↓

Insulate bare wire with insulating tape or insulate splice with wire connector or insulating tape. Recheck continuity between separate power wires to confirm repair of short circuit.

↓

Reconnect disconnected wires and restore power.

END

Figure 7-21.—Troubleshooting chart for a short circuit fault in a power circuit.

Figure 7-20 is a power circuit ground fault troubleshooting diagram. Figure 7-21 is a similar diagram for a short-circuit fault in the same wiring.

Open Circuits

An open-circuit fault in one of the lines supplying the fire alarm system will cause signs of power failure, but circuit breakers or fuses may show normal conditions. If the fire alarm control unit has a power failure or trouble signal feature, it will be activated, indicating that a problem exists. Refer to figure 7-22, which is a troubleshooting chart for this condition.

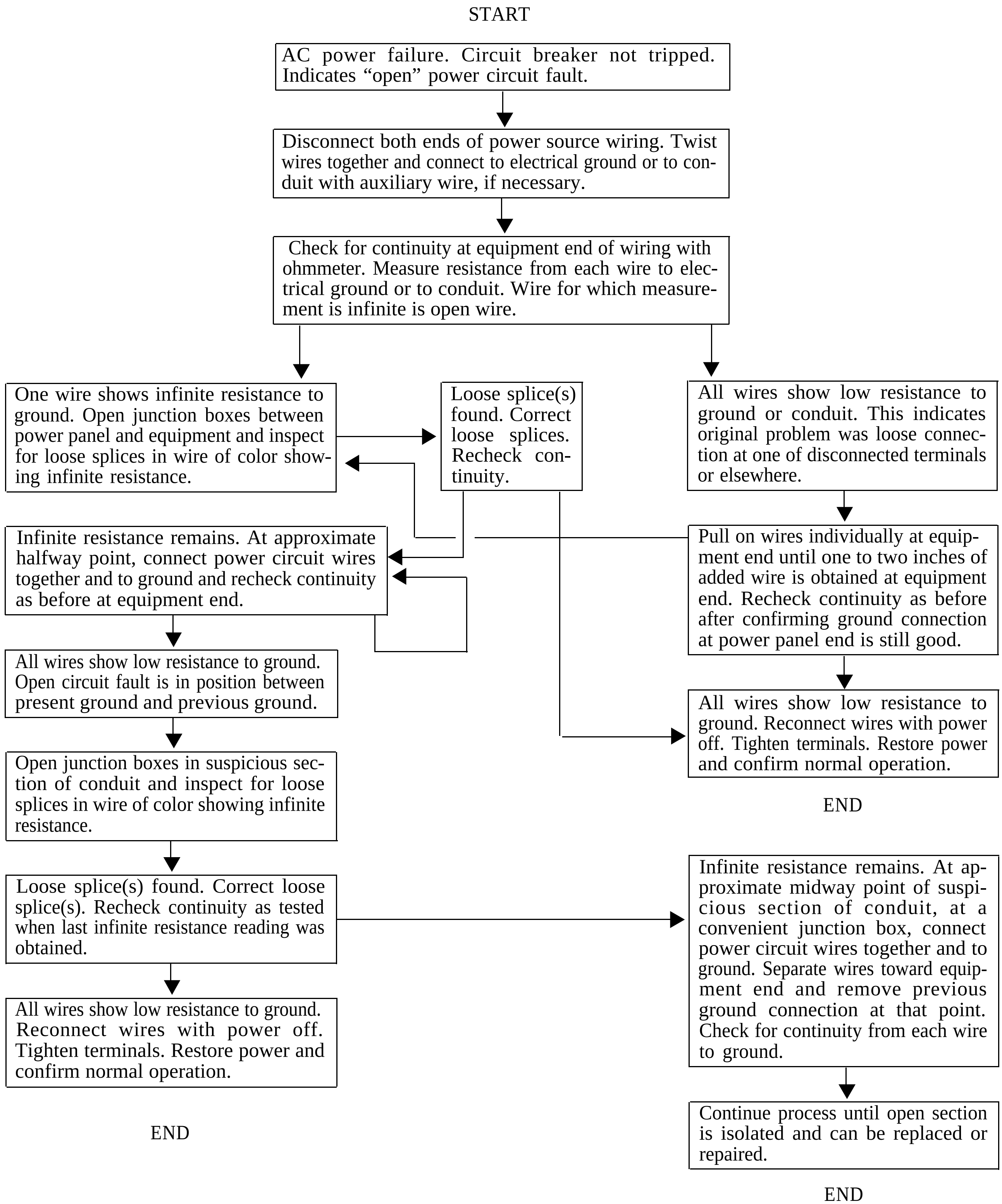

Figure 7-22.—Troubleshooting chart for an open fault in power circuit.

INITIATING CIRCUIT FAULTS

Initiating circuits, like power supply circuits, may experience shorts, opens, or ground faults. Operating tests of initiating circuits to locate and repair faults are best performed after normal working hours to avoid disruption of normal activities.

Short Circuit

A short circuit between two points on the same side of the circuit does not harm system operation and is normally not detected unless the short circuit also involves one or more ground faults. A short circuit between wires on opposite sides of the circuit causes an alarm. A clue to this condition is the fact that an alarm condition exists for an initiating circuit, but inspection shows that none of the initiating devices connected to that circuit have operated. The following trouble-shooting steps will guide you in finding and repairing the fault:

1. Tag and disconnect the initiating circuit loop at the control unit or annunciator terminals.
2. Measure the initiating circuit resistance with an ohmmeter. A value of 100 ohms or less confirms a short circuit. The lower the value, the closer to the source the fault is located. A measurement equal to the end-of-line resistor value or slightly higher is normal and suggests looking in the control unit or annunciator for the fault. (Determine the proper value of the resistor, usually 1,000 to 2,000 ohms, from reference materials on the equipment.)
3. If resistance measured is low, confirming a short circuit, move to a point that is electrically about halfway between the source and the end-of-line resistor for the next resistance measurement. A low resistance, near zero, indicates the short circuit is quite near the test point. A resistance of 50 to 100 ohms indicates that the circuit is a long one of smaller gauge wire and that the short-circuit fault is near the end of the circuit. At each new test location, break both sides of the circuit by disconnecting wires at a convenient initiating device or junction box. Measure circuit resistance in the direction toward the end of the circuit.
4. Low resistance measured from the second location, less than 100 ohms, indicates the short circuit is still farther toward the end of the circuit. High resistance, approximating the end-of-line resistor value, indicates that the short circuit is closer to the control unit.
5. Continue moving toward the short circuit, dividing the circuit approximately in halves each time, and repeat the measurement of resistance toward the end of the circuit using the guidelines in Step 4 as the rule for interpreting each succeeding measurement.
6. When the fault is located, repair it, reconnect the disconnected wires, and restore the circuit to normal service.

Open Circuit

An open-circuit fault in an initiating circuit stops the supervising current. The trouble relay at the control unit or annunciator de-energizes, and trouble indicators are activated for the circuit. Initiating devices closer to the control unit or annunciator than the open fault may continue to function. Devices beyond the fault cannot operate. If an open-circuit fault occurs, turn off any audible trouble signals by operating the trouble silence switch. Continue troubleshooting by using the following steps:

1. Tag and disconnect the initiating circuit loop at the control unit or annunciator terminals.
2. Measure the initiating circuit resistance with an ohmmeter. An infinite reading (no change in meter reading from the reading with the meter disconnected from the circuit) confirms an open-circuit fault. A measurement equal to the end-of-line resistor value, or slightly higher, is normal and suggests looking in the control unit or annunciator for the fault.
3. If the open-circuit fault is confirmed, leave the two circuit wires off their terminals, taped separately. Move to a point that is electrically about halfway between the source and the end-of-line resistor for the next resistance measurement. Choose a convenient initiating device or junction box and measure resistance across the two sides of the initiating circuit. If the measurement is still infinite, the open-circuit fault is still farther along the circuit toward the end-of-line resistor. If the measurement is now about equal to the end-of-line resistor value, the open-circuit fault is between the present measurement point and the source.
4. Move toward the fault to a point electrically about halfway between the present measurement point and the end-of-line resistor or

the source, and measure resistance across the circuit.

5. Infinite readings indicate the open-circuit fault is toward the end-of-line resistor from the new test point. Readings approximating the end-of-line resistor value indicate the open-circuit fault is toward the source.

6. Continue taking new readings, advancing toward the fault. Look especially for loose connections at splices and at initiating-device screw terminals.

7. When the fault is located, repair it, reconnect wires at the control unit or annunciator, and restore alarm service.

Grounded Circuit

A single ground fault on an initiating circuit should not cause any malfunction, but a circuit trouble indication may be caused at the control unit or annunciator if ground-fault detection is a feature of the equipment. Even a single fault should be corrected so that a possible additional fault will not cause a serious deficiency in the alarm system. Two ground faults on opposite sides of the initiating circuit cause a short circuit between the two faults. Follow troubleshooting directions described earlier for a short-circuit fault.

Troubleshoot for a single ground fault using the following steps:

1. Tag and disconnect the initiating circuit at the control unit or annunciator terminals.

2. With an ohmmeter, check for continuity between each end of the circuit and an unpainted spot on the electrical conduit or another ground connection, such as a cold-water pipe.

3. Continuity confirms that at least one circuit ground fault exists. An infinite reading suggests looking in the control unit or annunciator for the ground fault.

4. At a point that is electrically about halfway between the source and the end-of-line resistor, break both sides of the circuit by disconnecting wires at a convenient initiating device or junction box. Check for continuity between each wire and ground separately.

5. Each time continuity to ground is found, move toward the ground fault at a new test point about halfway between the present test point and the last previous test point or the end of the circuit in that direction (source or end-of-line resistor). Look especially for wet, pinched, and damaged wire.

6. When the fault is located, repair it, reconnect wires at the control unit or annunciator, and restore alarm service.

INDICATING CIRCUIT FAULTS

An open- or short-circuit fault in an indicating circuit causes a trouble indication at the control unit. A ground fault may also cause a trouble indication if ground-fault detection is a feature of the control unit.

Short Circuit

A short-circuit fault in an indicating circuit is difficult to detect by the usual test methods because the normal circuit resistance is quite low. A short circuit is just a low resistance in parallel with the low-resistance indicating devices.

The symptoms would be a blown fuse at the control unit or power supply during a routine system test or fire drill and audible devices that do not operate as loudly as usual.

If you suspect a short-circuit fault, the following troubleshooting steps may help locate the fault:

1. There may be several indicating circuits powered from one power supply or fuse in the control unit. Separate the several circuits from each other by tagging the wires and disconnecting them from the control. unit terminals. It may be necessary to make continuity measurements to confirm that the wires from each circuit are tagged separately. Compare the resistance readings for the indicating circuits using the $\times 1$ resistance range of the ohmmeter. If there is a short-circuit fault, that circuit should have a lower resistance reading than the others. Insulate with tape the individual bare wires of the circuit being checked.

2. Determine how the circuit wires are routed, using the best available information you may have to trace the wire or conduit route. Move to a point electrically about halfway between the control unit and the most distant indicating device for the next check. At a convenient initiating device or junction box, separate the wires leading back to the control unit from those leading to the more distant indicating devices by disconnecting them at device terminals or at splices. Measure circuit resistance in both directions. The short-circuit fault should be in the direction of the lower resistance.

3. Move toward the fault to a new test point about halfway between the present test point and the last test point or the end of the circuit in that direction (power source or last indicating device). Separate the wires toward the control unit from those leading away from the control unit and again measure the circuit resistance on the × 1 scale of the ohmmeter in both directions. The fault will be in the low-resistance direction.

4. Continue to move toward the fault, looking for pinched and damaged wires and for improper connections at indicating devices. Make careful measurements at each new test point since the difference between normal and abnormal resistance may be only slight.

5. When the fault is located, repair it, reconnect all wires, test the indicating devices, and restore the alarm system to service.

Open Circuit

In a two-wire parallel circuit, one open-circuit fault near the control unit would deactivate all the indicating devices. The only sign of an open-circuit fault is the failure of one or more indicating devices during an alarm system test or fire drill. The following troubleshooting steps will help locate the fault:

1. Operate the system test or drill switch at the control unit and check the operation of each indicating device on the suspected faulty circuit.

2. Check the circuit connections at any device with intermittent or weak signals. If a group does not work, check circuit connections at the working and nonworking devices at each end of the group. Make sure that terminal screws are clean and snug and that there are no broken wires at the devices checked.

3. If the fault was not located in Step 2, check the wiring between working and nonworking devices, looking especially for poor splice connections at junction boxes.

4. If all the indicating devices on a circuit fail to work, check for a blown fuse or poor connections at the control unit or at the first indicating device on the circuit.

5. When the open-circuit fault is found, repair the fault and retest the indicating circuit to confirm that all indicating devices work properly.

Grounded Circuit

A single ground fault in an indicating circuit may not cause any symptoms unless the indicating circuit is ac-line powered. If the ground fault is on the “hot” side of the ac circuit and the indicating circuit is tested, a fuse or circuit breaker at the control unit or at the power panel supplying the alarm system will blow. A ground fault on the neutral side of the indicating circuit causes no symptoms. Two ground faults on opposite sides of the indicating circuit are also a short circuit. Troubleshooting for the short circuit may be accomplished as described earlier.

Troubleshoot for a ground fault using the following steps:

1. Tag and disconnect the indicating circuit wires at the control unit.

2. With an ohmmeter, check for continuity between each circuit wire and an unpainted spot on the electrical conduit or another ground connection, such as a cold-water pipe.

3. Continuity confirms that there is at least one circuit ground fault. An infinite reading suggests looking in the control unit for the ground fault.

4. If a ground fault in the indicating circuit is confirmed, insulate the bare ends of the circuit wires with tape. Move to a point electrically about halfway between the control unit and the most distant indicating device on the circuit. At a convenient indicating device or junction box, separate the wires leading back to the control unit from those leading to the more distance devices by disconnecting them at device terminals or at splices. Check again for continuity between each wire and ground separately.

5. Each time continuity to ground is found, move toward the ground fault at a new test point about halfway between the present test point and the last test point or end of the circuit in that direction. Look especially for wet, pinched, and damaged wires.

6. When the fault is located, repair it, reconnect all wires, and test the indicating circuit by operating the drill or test switch. If all devices operate properly, restore the alarm system to service.

INTRUSION ALARMS

So many types of intrusion alarm systems or combination systems are available today that a detailed discussion here would not be practical. Each alarm system is of a special nature, and no two systems will ever be identical. For more information on intrusion detection systems, refer to Design Manual 13.02.

In this section, we will cover one intrusion system developed to be used by all branches of the service. This system is called joint service interior intrusion detection system (JSIIDS). The system has been designed to protect small arms, ammunition, and sensitive materials in storage.

Purpose

JSIIDS was designed to DETECT, not prevent, an attempted intrusion. The main purpose of JSIIDS or any other alarm is to give the earliest possible notice of an attempted intrusion. The more notice the reaction force (security police) has before the intruder gets past the outer boundaries, the better the chance that the intruder will be caught.

Components

The various components of JSIIDS are of two general classes: (1) the control unit and its sensor components and (2) the monitor and display equipment.

CONTROL UNIT.—The control unit is the central control element of the JSIIDS. It is located within the protected area. It receives and processes the intrusion tamper and duress alarm signals generated at the sensors.

The control unit contains an emergency standby power supply (battery) with an automatic switchover when primary ac power is lost. It operates in much the same manner as emergency lights do.

The JSIIDS mode of operation is controlled by a key switch mounted on the control unit door. Three modes of operation are provided as follows:

1. Secure—when the protected area is not open to authorized personnel. In this mode, all alarms are processed.
2. Access—when the area is open to authorized personnel. In this mode, only tamper and duress alarms are processed.
3. Test/Reset—when electricians perform tests and maintenance. All alarms are processed, and a sounding device operates for 10 seconds at the control unit to aid in testing.

SENSOR.—There are four classes of sensor components associated with the control unit. They are classified as follows:

1. Penetration sensors-those designed to detect penetration into the protected area through doors, windows, walls, floors, ceilings, and other openings in the room.
2. Motion sensors-those designed to detect movement of a person within the protected area.
3. Point sensor-those designed to detect the attempted removal of an item from its normal position in the protected area, such as removal of a rifle from a weapons rack.
4. Duress sensor-those designed to be activated by guard personnel to call for help under a duress situation.

MONITOR CABINET.—The monitoring and display equipment is the primary notification equipment of the JSIIDS. The monitor cabinet has a self-contained signal module and primary and emergency power supply. The signal module displays the status of the monitor cabinet power supply; that is, operation on the primary or emergency power source.

DISPLAY EQUIPMENT.—The display equipment is located in an area where monitoring personnel are on duty 24 hours a day. The monitoring equipment consists of a status module or an alarm module, one for each control unit.

Status Monitor Module.—The status monitor module displays the status and mode of operation of one control unit. By looking at the lights on the status monitor module, the monitoring personnel can tell what is taking place in the protected structure.

Alarm Monitor Module.-The alarm monitor module is used in the monitor cabinets when only an alarm indication is required.

THEORY OF OPERATION

JSIIDS operates on the basic theory of a 20-volt dc circuit that has less than 2,000 ohms of resistance being supplied to the detector or detector processors. This voltage is provided from the control unit. A rise in ohmic value of the circuit to 100,000 ohms will trigger an alarm or tamper condition in the control unit.

If you think about that for just a minute, isn’t that the way our supervised fire alarm circuit operates? Sure it is! One main point to remember in any alarm system is that a small change in current flow (less than one-tenth of an ampere) can be used to activate an alarm. Our basic Ohm’s law provides that a rise in resistance causes a drop in amperage in the same circuit.

When the control cabinet receives an alarm or tamper signal, it then transmits the signal over telephone lines to the monitor cabinet.

INSTALLATION

The installation of components of the JSIIDS must comply with the current edition of the *National Electrical Code*® (NFPA No. 70) and with the following requirements for component mounting, conduit, and conductors.

Component Mounting

Wall-mounted components are designed to be held by fasteners that are accessible only through the open door or cover of the component. Before components are mounted, conduit holes should be cut in the enclosure if they are not already provided. All holes should be made with a half-inch chassis punch.

CAUTION

NEVER use a hole saw, since it produces metal shavings that can harm the performance of the equipment.

Conduit

All conductors except phone lines outside the protected area are to be installed in rigid galvanized steel conduit or intermediate metal conduit in accordance with article 345 of the *NEC*®. Conduit outlet boxes, pull boxes, junction boxes, conduit fittings, and similar enclosures are to be cast metal or malleable metal with threaded hubs or bodies. Conduit for JSIIDS circuits are NOT to contain any building wiring.

Conduit is required to be at least one-half inch in size. All requirements for tapered threads, supports, bends, locknuts, and bushings are the same as discussed under hazardous wiring.

Covers on pull and junction boxes used in the installation of the system have to have a tamper switch installed, or be tack-welded, brazed, filled with epoxy, or provided with twist-off screws.

Interior Conductors

Power conductors for 120-volt ac power to control units and monitor cabinets are to be solid copper, no smaller than No. 14 AWG, type RW or RH-RW or THW insulation.

Low-voltage conductors are to be no smaller than No. 22 AWG. They are to be installed using crimp-on spade terminal lugs at all wire connections to threaded screws on component terminal boards.

All neutral conductors and noncurrent-carrying metal parts of equipment have to be grounded.

A wiring diagram of the installed system will be drawn up for each protected area. The diagram should indicate which sensors are installed and show color-coded interconnections between each sensor and the control unit. The diagram will aid in maintenance and troubleshooting. The diagram should be classified confidential and placed in an appropriate security container.

Connections

All requirements for installation and component connections for the JSIIDS will be found in the manufacturers' literature. Foldouts are provided, showing block diagrams that include each component used by the JSIIDS. One point you should remember is that JSIIDS components are manufactured by several manufacturers using government specifications. Always check the terminal boards before connecting your conductors. Although one system may have terminals numbered from left to right, the terminals on the next system you install may be numbered from right to left. Always check before you connect.

MAINTENANCE

The JSIIDS should be inspected on a monthly basis as part of your shop's recurring maintenance program. Always inform the reaction force or law enforcement desk before you begin. The system is vulnerable to compromise during maintenance, and for this reason, personnel of the alarm crew should request a security person to accompany them for their own protection. You should alter the schedule of your inspections with a different routine each month.

General maintenance of the JSIIDS includes a visual inspection of all equipment, conduits, and boxes. Look for signs of tampering and loose straps or screws, and observe the general condition of flexible cords or conduits.

Perform an operation test on all installed sensors, check the power supply for proper voltages, and check the condition of the battery. Return all functions of the system to normal operation, and call the law enforcement desk before leaving.

Maintenance procedures for the control unit and each sensor component are listed in the manufacturers' literature.

TROUBLESHOOTING

The JSIIDS was designed for fast, easy troubleshooting. Inside the control unit is a component called the status processor.

Mounted inside the processor are printed circuit boards (PCBs). There is one PCB for the duress switches and one for each group of additional sensors. This means that the group of motion sensors terminate to one PCB, the door contacts to another PCB, and so on. LEDs are installed in the last PCB. An LED looks like a small red lamp that illuminates when the processor receives the initial alarm input. The LED will remain illuminated until the system is reset.

When you open the control unit door, you can see immediately what sensor group triggered an alarm by checking for an illuminated LED.

Each PCB has test points for a voltmeter. The status of each sensor group can be checked at these test points for a tamper or alarm condition. An alarm condition will give a 20-volt dc reading. When the problem is cleared and the system is reset, the voltage should drop off to zero.

Most system malfunctions and troubles will come from a faulty power supply. The JSIIDS requires a constant 20 volts + or - 1 volt to operate. When the power supply starts breaking down, the voltage will start creeping up or down. A voltage reading of less than 19 volts dc or more than 21 volts dc requires the replacement of the power supply.

REPAIR

The major JSIIDS components are designed in modules. Repairs to the system are normally made by replacing the defective module. An example is the power supply. It can be replaced after disconnecting and tagging all conductors and removing four screws. The status processor can also be replaced by removing four screws, or a single PCB in the processor can be replaced by a snap-and-pull action. The new PCB is then inserted into the processor.

Minor repairs on some components can be completed with the aid of a soldering gun. These components are toggle switches, fuse holders, the mode switch, and so on.

Your main concern is to repair the system as soon as possible and bring it back on line. The defective components can then be shipped back to the manufacturer for replacement.

The main point to remember when replacing JSIIDS components is to TAG YOUR CONDUCTORS. One conductor out of place can cause you hours of downtime troubleshooting.